Claims

I claim:

1. A method for injecting ions into a quadrupole ion trap mass spectrometer (QIT-MS), comprising:

cycling a QIT-MS through a plurality of radiofrequency (RF) amplitude levels, each RF amplitude level corresponding to the storing of ions in one of a corresponding plurality of ranges of ion mass-to-charge ratios;

incidenting a plurality of laser pulses on a sample during cycling the QIT-MS through a plurality of RF amplitude levels, wherein sample ions are generated each time one of the plurality of laser pulses in incident on the sample; and

injecting the sample ions generated each time one of the plurality of laser pulses is incident on the sample into the QIT-MS such that a corresponding plurality of ion pulses is produced;

wherein incidenting the plurality of laser pulses on the sample is synchronized with cycling of the QIT-MS through the plurality of RF amplitude levels such that the same number of ion pulses are produced during each of the plurality of RF amplitude levels.

2. The method according to claim 1,
wherein the QIT-MS is a 3-dimensional QIT-MS (3D-QIT-MS).

3. The method according to claim 1,
wherein the QIT-MS is a linear QIT-MS (L-QIT-MS).

4. The method according to claim 1,
wherein one ion pulse is produced during each of the plurality of RF amplitude levels.

5. The method according to claim 1,

wherein at least two ion pulses are produced during each of the plurality of RF amplitude levels.

6. The method according to claim 1,

wherein each ion pulse of the plurality of ion pulses is of an approximately equal duration.

7. The method according to claim 6,

wherein each of the RF amplitude levels is maintained for a period of time corresponding to the duration of one of the ion pulses.

8. The method according to claim 5,

wherein each of the RF amplitude levels is maintained for a period of time corresponding to the duration of the at least two ion pulses.

9. The method according to claim 1,

wherein the duration of the ion pulses produced during each of the RF amplitude levels is approximately equal.

10. The method according to claim 1,

wherein incidenting a plurality of laser pulses on the sample results in atmospheric pressure laser desorption (AP-LD) each time a laser pulse is incident on the sample.

11. The method according to claim 1,

wherein incidenting a plurality of laser pulses on the sample results in atmospheric pressure matrix assisted laser desorption ionization (AP-MALDI) each time a laser pulse is incident on the sample.

12. The method according to claim 1,

wherein incidenting a plurality of laser pulses on the sample results in atmospheric pressure laser desorption/ionization from porous silicon (AP-DIOS) each time a laser pulse is incident on the sample.

13. The method according to claim 1,

wherein incidenting a plurality of laser pulses on the sample results in laser desorption-atmospheric pressure chemical ionization (LD-APCI) each time a laser pulse is incident on the sample.

14. The method according to claim 1,

wherein synchronizing incidenting the plurality of laser pulses on the sample with cycling of the QIT-MS through the plurality of RF amplitude levels is accomplished by controlling the pulse frequency of the laser such that the laser pulses are synchronized with changes in RF amplitude levels of the QIT-MS.

15. The method according to claim 1,

wherein the plurality of laser pulses is generated by a laser operating at a repetition rate of between about 10 Hz and about 100 Hz.

16. The method according to claim 1,

wherein the plurality of laser pulses is generated by a laser operating at a repetition rate of between about 1HZ and about 10Hz.

17. The method according to claim 1,

wherein the plurality of laser pulses is generated by a laser operating at a repetition rate of between about 100Hz and about 1000Hz.

18. The method according to claim 1,

wherein synchronizing incidenting the plurality of laser pulses on the sample with cycling of the QIT-MS through the plurality of RF amplitude levels is accomplished by modifying software code of the QIT-MS.

19. The method according to claim 1,

wherein cycling of the QIT-MS through a plurality of RF amplitude levels comprises timing the RF amplitude level changes to coincide with the duration of an ion pulse.

20. The method according to claim 1, further comprising:

cycling the QIT-MS through a QIT-MS scan; and

turning off the laser pulses during portions of the QIT-MS scan which are not related to the injection of the sample ions.

21. The method according to claim 1, further comprising:

cycling the QIT-MS through one or more of the following portions of a QIT-MS scan:

mass analysis portion, pre-injection portion, post-injection portion, multiplier rise time, and post-scan portion; and

turning off the laser pulses during at least one of the one or more portions of a QIT-MS scan through which the QIT-MS is cycled.

22. The method according to claim 1,

wherein injecting the sample ions generated each time one of the plurality of laser pulses is incident on the sample into the QIT-MS occurs during an injection period of a QIT-MS scan.

23. The method according to claim 13,

wherein the duration of the injection period is between about 40 ms and about 200 ms.

24. The method according to claim 1,

wherein one laser pulse is incident on the sample during each of the plurality of RF amplitude levels.

25. The method according to claim 1,

wherein at least two laser pulses are incident on the sample during each of the plurality of RF amplitude levels.

26. The method according to claim 1,

wherein the plurality of laser pulses is generated by a laser operating at a repetition rate which results in an approximately continuous supply of ions.

27. The method according to claim 26,

wherein the repetition rate of the laser is approximately $1/T_{IP}$, where T_{IP} is the width of one of the plurality of ion pulses.

28. The method according to claim 26, further comprising:

utilizing automatic gain control (AGC).

29. The method according to claim 26,

wherein QIT-MS control software causes the temporal pulse width of the plurality of ion pulses to be monitored by the QIT-MS and the repetition rate of the laser to be adjusted such that an approximately continuous supply of ion is maintained.

30. An apparatus for injecting ions into a quadrupole ion trap mass spectrometer (QIT-MS), comprising:

a means for cycling a QIT-MS through a plurality of radiofrequency (RF) amplitude levels, each RF amplitude level corresponding to the storing of ions in one of a corresponding plurality of ranges of ion mass-to-charge ratios;

a means for incidenting a plurality of laser pulses on a sample during cycling the QIT-MS through a plurality of RF amplitude levels, wherein sample ions are generated each time one of the plurality of laser pulses is incident on the sample; and

a means for injecting the sample ions generated each time one of the plurality of laser pulses is incident on the sample into the QIT-MS such that a corresponding plurality of ion pulses is produced,

wherein the means for incidenting a plurality of laser pulses on the sample is synchronized with the means for cycling the QIT-MS through a plurality of RF amplitude levels such that the same number of ion pulses are produced during each of the plurality of RF amplitude levels.

31. The apparatus according to claim 30,
wherein the QIT-MS is a 3-dimensional QIT-MS (3D-QIT-MS).

32. The apparatus according to claim 30, wherein the QIT-MS is a linear QIT-MS (L-QIT-MS).

33. The apparatus according to claim 30,

wherein the means for incidenting a plurality of laser pulses on the sample is synchronized with the means for cycling the QIT-MS through a plurality of RF amplitude levels such that one ion pulse is produced during each of the plurality of RF amplitude levels.

34. The apparatus according to claim 30,

wherein the means for incidenting a plurality of laser pulses on the sample is synchronized with the means for cycling the QIT-MS through a plurality of RF amplitude

levels such that each ion pulse of the plurality of ion pulses is of an approximately equal duration.

35. The apparatus according to claim 34,

wherein the means for cycling a QIT-MS through a plurality of RF amplitude levels maintains each of the RF amplitude levels for a period of time corresponding to the duration of one of the ion pulses.

36. The apparatus according to claim 30,

wherein the means for incidenting a plurality of laser pulses on the sample is synchronized with the means for cycling the QIT-MS through a plurality of RF amplitude levels such that the duration of the ion pulses produced during each of the RF amplitude levels is approximately equal.

37. The apparatus according to claim 30,

wherein the means for incidenting a plurality of laser pulses on the sample causes atmospheric pressure laser desorption (AP-LD) each time a laser pulse is incident on the sample.

38. The apparatus according to claim 30,

wherein synchronizing the means for incidenting a plurality of laser pulses on the sample with the means for cycling of the QIT-MS through the plurality of RF amplitude levels is accomplished by controlling the pulse frequency of the laser such that the laser pulses are synchronized with changes in RF amplitude levels of the QIT-MS.

39. The apparatus according to claim 30,

wherein the means for incidenting a plurality of laser pulses on a sample comprises a laser operating at a repetition rate of between about 10 Hz and about 100 Hz.

40. The apparatus according to claim 30,

wherein the means for incidenting a plurality of laser pulses on a sample comprises a laser operating at a repetition rate of between about 1Hz and about 10Hz.

41. The apparatus according to claim 30,

wherein the means for incidenting a plurality of laser pulses on a sample comprises a laser operating at a repetition rate of between about 100Hz and about 1000Hz.

42. The apparatus according to claim 30,

wherein the means for cycling a QIT-MS through a plurality of RF amplitude levels comprises software code for the synchronizing the means for incidenting a plurality of laser pulses on the sample with the means for cycling a QIT-MS through a plurality of RF amplitude levels.

43. The apparatus according to claim 30,

wherein the means for cycling a QIT-MS through a plurality of RF amplitude levels comprises a means for timing the RF amplitude level changes to coincide with the duration of an ion pulse.

44. The apparatus according to claim 30, further comprising:

a means for cycling the QIT-MS through a QIT-MS scan,

wherein the means for incidenting a plurality of laser pulses on sample comprises a means for turning off the laser pulses during portions of the QIT-MS scan which are not related to the injection of the ions.

45. The apparatus according to claim 30:

wherein the means for cycling a QIT-MS through a plurality of RF amplitude levels comprises a means for cycling the QIT-MS through one or more of the following portions of a QIT-MS scan:

mass analysis portion, pre-injection portion, post-injection portion, multiplier rise time, and post-scan portion,

wherein the means for incidenting a plurality of laser pulses on a sample comprises a means for turning off the laser pulses during at least one of the one or more portions of a QIT-MS scan.

46. The apparatus according to claim 30:

wherein the means for incidenting a plurality of laser pulses on the sample is synchronized with the means for cycling the QIT-MS through a plurality of RF amplitude levels such that one laser pulse is incident on the sample during each of the plurality of RF amplitude levels.

47. The apparatus according to claim 30,

wherein the means for incidenting a plurality of laser pulses on a sample incidents the plurality of laser pulses at a repetition rate which results in an approximately continuous supply of ions.

48. The apparatus according to claim 47,

wherein the repetition rate is approximately $1/T_{IP}$, where T_{IP} is the width of one of the plurality of ion pulses.

49. The apparatus according to claim 47, further comprising:

a means for utilizing automatic gain control with respect to QTI-MS.

50. A method for injecting ions into a quadrupole ion trap mass spectrometer (QIT-MS), comprising:

cycling a QIT-MS through a QIT-MS scan having an ion injection period, wherein ions can be injected into the QIT-MS during the ion injection period,

incidenting a plurality of laser pulses on a sample during the QIT-MS scan, wherein sample ions are generated each time one of the plurality of laser pulses in incident on the sample; and

injecting the sample ions generated each time one of the plurality of laser pulses is incident on the sample into the QIT-MS such that a corresponding plurality of ion pulses is produced;

wherein incidenting the plurality of laser pulses on the sample is stopped during at least a portion of the time period outside of the ion injection period of the QIT-MS scan.

51. The method according to claim 50,

wherein incidenting the plurality of laser pulses on the sample is stopped during substantially all of the portion of the time period outside of the ion injection period of the QIT-MS scan.

52. The method according to claim 50,

wherein cycling the QIT-MS through a QIT-MS scan having ion injection period comprises cycling the QIT-MS through a plurality of radiofrequency (RF) amplitude levels during the ion injection period, each RF amplitude level corresponding to the storing of ions in one of a corresponding plurality of ranges of ion mass-to-charge ratios.

53. The method according to claim 50,

wherein the QIT-MS is a 3-dimensional QIT-MS (3D-QIT-MS).

54. The method according to claim 50,

wherein the QIT-MS is a linear QIT-MS (L-QIT-MS).